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A Place-theoretical Framework for the Development of Ubicomp in Urban Places

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ABSTRACT
This article is based on the research with the same name that is being carried out at the school of Architecture of the University of Sheffield. It discusses the physicality of Ubiquitous Computing (Ubicomp), introducing some analytic resources for thinking about problems and possibilities in the incorporation of IT into the design of public spaces. Some concepts and the result of an experiment are summarized, drawing up final conclusions and suggesting new researches.

Categories and Subject Descriptors
J5: Computer applications: Arts and Humanities: Architecture

General Terms
Design, Theory.

Keywords
Ubiquitous Computing, Pervasive Computing, Architecture, Urban Design

1. INTRODUCTION
Ubiquitous computing is the model of human-computer interaction through which information processing capabilities are accessed within the environment. By embedding devices and pervading resources of Information Technology (IT) in quotidian scenes, everyday objects and their spatial resources became interfaces to detect and react to people’s activities. In accordance to those concepts, physicality of Ubicomp systems can be expressed by the set of physical characteristics that can act as part of that interaction. It comprises the study of the environment and of IT components to disclose their complementary spatiality in order to assemble them into integrated systems.

2. INITIAL CONCEPT
It is assumed here that the main purpose of the built environment is to provide support to dwell. In this sense, “place” means a differentiated and qualified space that supports dwelling and IT is regarded as being able to improve dwelling when applied as Ubicomp system. In other words, the meaning of Ubicomp physicality is to support dwelling as an integrated resource with the physical environment.

3. QUALITIES OF THE PLACE
Malard [1] has studied the qualities of place. From Heidegger [2] she assumed that place is equipment to dwell. Souza [3] commented that Heidegger extended this meaning to open and public spaces, by considering that they provide inhabitability to support human activities [4]. Thus, public place is understood here as space qualified to support dwelling. Investigating about dwelling, Korosec-Serfaty [5] proposed three fundamental physical characteristics:

3.1 Setting up an inside/outside:
Changing space into place is a process of qualification and differentiation. Differentiation is the process of choosing, defining, marking and building places. It is achieved by doing some work in the place, for instance, by implementing markers and signs, building walls, planting trees and the like. Setting up an inside/outside is a question of establishing boundaries that qualify the space. Dwelling is to be inside (in a place) as opposed to being outside (in the infinite space). Qualification is the assignment, the in-order-to, the involvement of the place with man’s activities. Man
creates places by differentiating and qualifying spaces to perform his activities. Therefore, all built environments are submitted to this process of setting up an inside/outside, this limit of territory which also is the process of distinguishing what is private from what is public (figure 1). By demarcating and differentiating dwelling places, humans put down roots and establish existential connections with them. Therefore it may be concluded that the phenomenological dimension of the dwelling process, which consists of setting up an inside/outside, causes qualities as territoriality, identity and privacy.

3.2 Visibility: The hidden and the visible
From the opposition inside/outside emerges the characteristic of visibility. Any dwelling can be both, closed or open, visible or concealed, at the same time. Because the dwelling is open to the outside and, at the same time, encloses the inside, it conceals and shows, it is secrecy and display. The phenomena related to this dimension are privacy and preservation of identity (Figure 2).

![Figure 2: control of visibility](image)

3.3 Appropriation
Appropriation of the dwelling is acting and taking care. It is to be connected with some place, its present, its past and its future. Appropriation also is related to the quality of ambience, which is the need of being comfortable while living. Almost all qualities of the place-object are, to a certain extent, related to ambience. Nevertheless, to be properly appropriated, places need to be comfortable, in terms of layout, temperature, ventilation, illumination and the like.

![Figure 3: different internal areas: appropriation](image)

4. QUALITIES OF PLACE
Those latter three characteristics proposed by Korosec-Serfaty could be encompassed by four basic concepts that are the qualities of place [1, 6, 7]: Territoriality, Privacy, Identity, and Ambience. Territoriality is the process in which an area is maintained in order to preserve and protect an individual or group. The actions to protect an area are termed territorial behaviour. Territorial behaviour includes all the devices that use the space with that aim. The territorial quality is related to human purposes when humans give a sense of appropriation to the space, generating marks to identify the place boundaries. At the same time, it generates marks, delineating the space, granting identity, showing to the members of a community who live inside how they can recognize their limits. The social interaction inside a territory is ruled by the dominant group in order to improve their defence.

Privacy is the selective control of the access to a person or a group. It can be described as a control process of interpersonal events, permitting to take part in the social life, controlling by denying or permitting the web of relationship established by the social collective. Desirable levels of privacy can be established by means of spatial, verbal and cultural behaviour. Normally, the common sense of privacy is obtained by using spatial elements to separate activities, or even using time, scheduling activities in order to separate them.

Identity is the set of beliefs, ideas, general qualities that make us sense we are at the same time unique and able to share social life values. Individually, identity promotes differentiation and individual distinction. Collectively, it gives elements that the individuals recognize as patterns to integrate a person into a group.

Ambience is a quality related to all those facts that turn the place into an enjoyable interior. It reaches a subjective dimension, in which one can experience emotional responses to a place. To observe this quality we need to interpret how people are willing to maintain the place, how they care to correctly use the equipments located in it, etc.

An analysis of the spatial phenomena related to the qualities of place will make clear how those qualities are related to the physical elements and people’s activities. However, we need to establish some terms in order to clear a referential group of words to refer to it.

5. ELEMENTS OF THE PLACE
This study has the hypothesis that Information Technology can integrate place’s spatiality when its elements perform in consonance with place’s topological structure. The elements of that spatiality were inferred from topological characteristics that were set out through many other studies about places and placeness[8-13]. Thus, elements of the place are topological arrangements of events that happen in the place and they can be referred to as centrality, internal directions, enclosure, internal area and entrances. Note that events are human activities that include the actual organization of the physical characteristics, as a register of past transformations. It means, for instance that a wall can be regarded as an event, despite not looking as “happening now”, it is a result of what happened in the past.

Looking at figure 4, an interior is defined by delimitating a chosen internal area (2) from the exterior. This delimitation implies in creating an enclosure (5) which involves an internal volume. A differentiated territory from the outside is created in this process. The quality achieved by this differentiation is territoriality. Once defined as the interior, its appropriation by people will generate centrality (1) that means a set of central points organized which identifies the internal area and help to organize hierarchies of events supporting the internal movements with best orientation. The events that happen inside the internal volume of the place can be meaningfully aligned in directions (3 and 4). The peculiarity of this alignment, in terms of visible characteristics, confers identity to the interior. The way people use, maintain and preserve that interior while appropriating it by their activities confers ambience. The visible form of the enclosure, from the outside, and the peculiarity
of its internal surfaces will confer identity to the place. The means by which the enclosure permits that the interior is visible or not and accessed or not from outside determines its privacy. The controlled connections with the outside are made by entrances (6), which visual aspects contribute to the identity. In the entrance, the issues related to the control of the fluxes contribute to privacy. Therefore, centrality, internal directions, enclosure, internal area and entrances are the primal components of the place, defined by the more stable and recurrent events that happen in it.

6. ELEMENTS OF UBICOMP

Components and functions of generic IT device, as a classification considering their spatial attributes were firstly clarified by Steve Shafer in his seminal paper “Ten Dimensions of Ubiquitous Computing”[14]. McCullough [15], inspired by Shafer’s list, has enumerated later ten essential components and functions by which Ubicomp can be studied. His description is a means to clarify to architects and designers how they could refer to IT applied in the environment. To McCullough [15], the components of Ubicomp are:

- **Components to sense the place**
  - Sensors can act on identity by sensing mechanical movements in terms of appropriation, according to embedded electronic tags. They can also permit users to visually identify specific elements according to conditions demanded by user’s status given by electronic tags. They interfere on place’s identity when they provide visual identification of users, according with user’s status given by electronic tags. They can also permit users to visually identify specific elements according to embedded electronic tags. In terms of appropriation, sensors can act on Identity by sensing mechanical movements in the adjustment process when people tune the system, permitting to know the user preferences while appropriating the place. Also interfering on the ambience, they can help to collect information about changes in temperature, pressure, light, permitting automatically trigger action to tune the system.

- **Components to modify the place**
  - Adjustments of the visibility of some elements, they can act on the adjustment process when people tune the system, permitting to automatically trigger action to tune the system.

- **Components to communicate**
  - Microprocessors, sensors, process and devices for tagging, links to communicate; actuators; control process; displays; determination of fixed Locations; software models; and tuning process.

Analysing both classifications of McCullough and Shafer in terms of spatial characteristics, it is possible to list their properties considering four categories, according to the relationship of the components and the place. So, an Ubicomp system has elements to sense the place; elements to modify and actuate in the place; elements that represent the place; and the place itself, as a referential matrix.

7. TOPOLOGY OF UBICOMP ELEMENTS

The four latter categories of Ubicomp were studied relatively to the physical properties of places. A table was used to specify the four place’s qualities and its related physical characteristics. Then, each Ubicomp component was analysed accordingly with its potential applicability, by the study of its technical features and how it can interfere over spatial instances. Table 1, in the end of this article, exemplifies this process.

8. UBICOMP SPATIALITY ANALYZED

Spatiality of Ubicomp describes each component relating its features to the topology of the place and describing how it can potentially interfere on the qualities of territoriality, privacy, identity and ambience. A following brief summarization can exemplify it, according to those components:

- **Components to sense the place** are all components and processes that sense modifications in the environment in terms of changes in some type of energy, transforming it into processed data and dispersing it to connected servers. Those components include microprocessors, sensors, tags, and communication links and all the spatial procedures where they are organized. To exemplify this category, we refer to the sensors, which function is to detect action in the place. They are electronic devices used to measure a physical quantity such as temperature, pressure or loudness and convert it into an electronic signal of some kind. They can act on place’s territoriality by detecting when moveable elements are inside or outside of pre-established delimitations. They can act on privacy by sensing proximity, invasion, permitting surveillance and informing when an action is needed to react against invasion. They can interfere on place’s identity when they provide visual identification of users, according with user’s status given by electronic tags. They can also permit users to visually identify specific elements according to embedded electronic tags. In terms of appropriation, sensors can act on Identity by sensing mechanical movements in the adjustment process when people tune the system, permitting to know the user preferences while appropriating the place. Also interfering on the ambience, they can help to collect information about changes in temperature, pressure, light, permitting automatically trigger action to tune the system.

- **Components to modify the place** are a group of elements to physically actuate in the place. They interfere in the environment physically by delivering some types of energy, and are named actuators, controls process and displays. To exemplify this category we mention the actuators. Probably, the idea of actuators is the most popular among architects who sometimes dare including robots and programmed mechanisms in their projects. An actuator is the mechanism by which an agent acts upon an environment. The agent can be either an artificial intelligent agent or any other autonomous being. They can interfere on territoriality by the servo mechanic adjustment of territorial enclosure as doors, walls, ceilings and canopies, floors, directions in the internal area, fences, and delimiters. Openness and visual barriers also can be controlled by servomechanisms, providing adjustments in privacy. With the adjustment of the visibility of some elements, they can act on the identity by changing enclosure shapes and textures. Adjustments of physical elements according to conditions demanded by user’s occupation, weight, physical efforts, movements, can also act on identity, interfering on appropriation of the place. Finally, when they act providing self cleaning functions and self adjustment of comfort conditions, like openness, wind and sound barriers, they interferes on the ambience.
Components to represent the place are a group of elements that represent the place in terms of model to adjust the whole system by processing data, simulating and predicting patterns of modifications in the environment. They include the techniques related to determining fixed location, designing and using software models and all tuning process of the system. Fixed Locations corresponds to strategic positions in the place through which information will be gathered or delivered or there will be an action caused by other IT components that can modify the place. It is a referential point to the representation of the whole IT system. Software model is a list of prescribed behaviours that the system can deal with. It informs mainly how sensing and acting has a closed correspondence, prescribing expected outcomes. Some models can include artificial intelligence, accumulating information about the environment and the users by learning them.

The tuning process refers to all sorts of services and devices that enable tuning the IT gears in the place. Such adjustment comprises defining scales of sensitiveness, accuracy of software models to represent the phenomena (events), and adjusting the physical presence of gadgets in located position. The place itself is a referential matrix, with the aforementioned components. It includes the events organized though the topology of the place. It consists of a set of parameters that guide this analysis.

9. SUPPORTING PROJECTS

The results of three different urban projects are now being analyzed in order to draw a conclusion about the limits and contributions of this framework to the creation of urban projects supported by Ubicomp. The first project (project A) was for the international contest of urban requalification of Gwangbok Street, South Korea, 2005. The second project (project B) was the urban requalification to Fargate Street, city of Sheffield, United Kingdom, 2006. The Third (project C) was the urban recast to the central area of the campus of the University of Sheffield, 2007. All projects had a common starting point that was to consider the application of IT as a means to contribute in the solution of spatial conflicts. Those urban areas were analyzed through the “reading space” technique proposed by Malard [1], observing conflicts originated from lack or malfunctioning of spatial elements in local activities. The conflicts were interpreted as interfering directly on the qualities of territoriality, privacy, identity and ambience. The architects of project B and C will be interviewed focusing their experience whilst using the framework. Project A intended to reconnect the street with a broader range of events that surround it in the neighbourhood. Busan is the city of the Korean Festival of Cinema, which attracts people all over the country to its celebrations. Originally Gwangbok Street was a calm commercial path that existed during the Korean middle ages. It has become nowadays a busy and congested street with many conflicts. The illegal parking at street obstructs it continuously causing conflicts with pedestrian activities. By its turn, pedestrian activities interfered over each other. The facades show a lack of maintenance that, together with many areas difficult to clean, interferes on the ambience. Also a wide variety of different types of urban furniture did not offer a sense of identity. Thousand of placards make Gwangbok to look as many other congested streets in Asia, nothing special, but a lack of identity. In addition, the city council was aiming to transform Gwangbok Street in a cultural pole, surrounded by a cast of buildings, open-markets, museums and other facilities in the range of walking distance.
Figure 10: Busan project, refurbishment of commercial street, South Korea, 2005

The project consisted of eight movable actuators, gadgets named “robots”. Each robot includes 1 Laser projector, 1 display message board, 2 big screen televisions, 2 video cameras, and 3 IBM’s Everywhere projectors. The laser projectors aimed to produce special visual effects in exhibitions and parades at nighttime. The luminous message board would broadcast news about activities in the street and around, information about local museums, events and so on. Televisions would permit watching small clips, ads, footages from the place, real time sequences, and others. Video cameras would gather material to be mastered and broadcasted through the Robots. The IBM’s Everywhere projector would combine projection with detection on arbitrary surfaces, converting walls and floor in an interactive touch screen. Each Robot would move under rails over the street, sustained by 34 structural portals. The Robots were made in molded polycarbonate and structural aluminum. They would be controlled by the Interaction Research Centre, situated inside the 4 towers along Gwangbok street. But the interaction, position, movement and lights of the Robot would be also modified by users through internet.

In the occasion of Busan International Film Festival or when required the Robot can spread information, ads, clips, games and quizzes about the movies exhibited, interacting with the public and attracting their attention. In order to be a pervasive mechanism for declaring, representing, and querying the physical relationship between people, places, devices, and things, the Robot would need a continuous research. The Interaction Research Centre would be an organization which main concern is designing, experimenting and maintaining systems, software and hardware, in order to produce new improvements on interactive urban devices used at Gwangbok Street.

Figure 11: Project B; Fargate Street at Sheffield, UK.

Project B was a refurbishment of an old commercial street at the centre of Sheffield. That street was bombed in the Second World War, and many buildings were rebuild. A report containing a list of conflicts affecting the qualities of the place was made to assist the architects design. The solutions comprised interactive walls, a ring for amusement, playing with local images and a kiosk for tourism information.

Project C was an urban recast of the public space at the Campus of University of Sheffield. Many conflicts were detected, from the lack of delimitations in the territory, causing confusion in people’s orientation, to the diversity of entrances and circulations reinforcing the transient character of occupation to the place, and so on. Two different systems of integrated solutions were designed, using IT devices and small physical interventions. In comparison with project A and B, the solutions were spatially less intrusive and the devices were more accurately specified.

Figure 12: Project C; Area at campus of the University of Sheffield.

10. Conclusions and future researches

Some points can be roughly inferred about the use of the framework by the architects in those projects:

A) The framework was introduced accomplished to the groups of architects in project C. It was partially accomplished when applied by the group in project B and was not applied at all in the project A. Project A was, as a matter of fact, inaccurate in terms of specifications of devices and rationale, being expensively intrusive, demanding extreme physical adaptations;

B) The technical specifications to the components of Information technology used in the projects became more concisely prescribed with the framework application. There was more reliability in their description as an integrated system with the place. At the same time, drawings to express the functioning of solutions became more abstract and hard to grasp;

C) The solutions designed solving each conflict through the use of the framework have provided more integration with each other. It means that each solution given interfered positively over the others and has helped to solve a bigger number of other detected conflicts;
D) There was a more rational use of technical resources of Information Technology to solve the conflicts addressed; justifications of the design were made with explicit references to place characteristics.
E) Once the solutions were designed more coherently as a system, they seemed to offer more flexibility for the design of new components and gadgets of Ubicomp. Their specifications were more related to located particularities, permitting a range of diverse technical solutions.

These observations have suggested that new researches could emphasize Ubicomp Design as a sort of problem-solving process, wondering how the design of the embodiment of IT, its physicality within the environment, is already attached to the place. It has also suggested that the design of Ubicomp systems requires new better approaches in the graphical representation of the solutions, requiring new researches to connect the fields of Design and Computer Sciences.

Table 1: sample of analysis of Ubicomp components relatively to the place.

<table>
<thead>
<tr>
<th>Territoriality</th>
<th>Privacy</th>
<th>Identity</th>
<th>Ambience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interiority and exteriority</td>
<td>Visibility</td>
<td>How do IT components relate to spatial situations of visibility of people, activities and spatial elements, considering a definition of interior/exterior and helping the quality “privacy”? This column describes some general applications related to visibility in what visibility is involved with the quality “privacy”.</td>
<td>Visibility</td>
</tr>
</tbody>
</table>

11. Acknowledgments
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12. References